Spring 2021

IE 445-102: Simulation Model Industrial Systems

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IE 445 Industrial Simulation

Mechanical and Industrial Engineering Department

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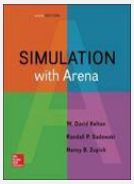
Course Text



Simulation with Arena

McGraw Hill; Kelton, W.D.,

Sadowski R.P., et al.
ISBN-13: 9780073401317
ISBN: 0073401315Edition: 6
Publisher: McGraw-Hill
Science/Engineering/Math

The pre-requisites for IE 445 are:
CIS 101 and IE 331 or equivalent.

Course Description

The most well known objective of the simulation modeling is to improve a system or a process, but most common use of simulation/animation is education. This course introduces the application of simulation modeling for the analysis of complex industrial, manufacturing, and social processes and systems. **Discrete Event Simulation Modeling** Techniques are used. Appropriate use of statistical Analysis tools are illustrated for Simulation Model Input and Output Data. Random Numbers and Variates, Goodness of Fit Tests for Data Distributions, Simulation Engine and Manual Simulation concepts are covered. Examples are selected from real-life problems and situations such as automated material handling, robotics, transportation, and hospital emergency rooms. Literature Review of the tools for Verification and validation of the models are completed by the students. Students will be able to complete a Simulation Model of a complex real life system and enhance its physical as well as economical efficiencies.

Course Software

1. Arena **ARENA** Simulation Software- *ArenaSimulation.com*

This is widely used software in the market for discrete event simulation. The students are introduced to the software early on in the class and they use the software to model and learn the various simulation exercises and execute the student projects. Also SIMIO is introduced. Arena student version can be downloaded from "***ArenaSimulation.com***" click Academics. Professional version is accessible from NJIT computer labs which are accessible remotely. Search

"Remote Access NJIT Labs" for current links to ITC labs. If a student semester project require professional version, use NJIT labs either remotely or in class. HW will use student version.

2. **Minitab & Microsoft Excel** ***ist.njit.edu/software***
   Used for statistical analysis of simulation results. Such as two-sample comparisons (t-test), more than two-sample comparisons (ANOVA) , and multi-factor and multi-sample analysis using design of experiments. Use of SAS or any other statistical software are also encouraged if desired. Students must download Minitab software from "***IST.njit.edu/Software***" after connecting via VPN to NJIT.

Computer software availability:

Online: Remote Access to Computer Labs are available:

Library and ITC-Stabile Lab has Arena -and Minitab. Manuals are available on-line

Course Objectives

By the end of the course the students would have learnt the following:

1. **Understand the concepts and the power of simulation modeling and analysis techniques**
   Students will be able to grasp what is simulation and where it is best used and how it is used through an examination of real-life examples. They will learn comparing simulation models of different scenarios to conduct what-if analysis to improve both economic efficiencies and the operational efficiencies of the system under study.

2. **Learn to build simulation models & use tools and calculate the performance measures.**
   https://www.arenasimulation.com/industry-solutions/healthcare-simulation-software
   Students will be encouraged to perform manual simulation (using Microsoft Excel) so that they understand how simulation models are built and how the simulation engines implement such models. Students also get hands-on experience with simulation tools used in the Industry such as Arena, with statistical tools i.e., Minitab & Excel (for random number generation).

3. **Familiarize and acquire knowledge of industrial simulation models**
   The emphasis in this course is on real-life problems. Throughout the course students will learn about Material handling processes, Manufacturing systems with transporters and conveyors, emergency systems simulation, Bank Teller etc.

4. **Learn classical statistical techniques for analysis of simulation data.**
   Students in this course will learn about randomness and statistical distributions that are appropriate for various types of data used in simulation models. They will be familiar with random numbers, random number variates, and goodness-of-fit tests. Students will analyze both the transient state and steady-state characteristics of simulation output data. The

course will illustrate the use of classical statistical techniques applied to simulation including the normal distribution, sampling, estimation and hypothesis testing, t-tests with equal variances and ANOVA.

5. **Learning to work as part of a team, taking responsibility and delivering it (Semester projects) and develop Communication skills –Presentation skills (Semester Projects) and working with high ethics (holding the university honor code).**

Examples: https://www.arenasimulation.com/industry-solutions/healthcare-simulation-software

Course Outline

- Introduction to Simulation
- General Principles of Simulation
- Simulation of Manufacturing Systems
- Statistical Models used in Simulation

Mid-Term Exam I

- Comparison and Evaluation of Alternate Systems
- Simulation Examples,
  Manual Simulation
- High Level Simulation Modeling

Mid-Term Exam II

- Arena Simulation Software
  - Input Modeling
  - Random Variate Generation
  - Goodness of Fit Tests

- Output Data Analysis: Confidence Intervals,
- Verification & Validation, Calibration of Models, Face Validity

Final Exam & Project Presentations

Course Grading

Exam 1	20%
Exam 2	20%
Final Exam	30%
Course Project	20%

Homework/Attendance 10%

There are 3 exams in the course; collectively they make up 70% of the grades, none of the exams are optional. The course project is **very important** in measuring the student outcome and makes up 20% of the grades. Students who are diligent in attending the classes regularly and submitting the assignments and taking part in class activities can earn as much as 10% of the grades. The major grading scale for the course is as follows:

Grade	C	B	A
Percentile	70-80	80-90	90-100

Course Project

Each student will take part in a team based course project(max 3 students) involving the application of simulation modeling and analysis on a case **study approved by the instructor**. The final report and project presentation is due the last day of the classes. Students are expected to use the Arena or Simio or any other simulation modeling software in their project. .

Availability of help:

- Just before and/or after class in the lab.
  office hours schedule: right after class or by appointment (bengu@njit.edu)

LITERATURE SEARCH -for projects : Useful Web Sites: Journals: *to search from-*

Students must search for Semester Project related professional articles (> 2 articles are required). Article search will help you in 3 ways. 1) to find if your project has been studied before, and how. Also a good article format 2) will guide you to design your technical report "Toble of contents" format. References of the article 3) will enlighten you for future possibilities of your study.

1. The Institute of Industrial Engineers IIE.
2. The Winter Simulation Conference Proceedings WSCP
3. The Michigan Simulation User Group (MSUG) MSUG.
4. An introductory overview here.
5. The Society for Computer Simulation SCS.
6. The Association for Computing Machinery has a special interest group in computer simulation, SIGSIM, ACM-SIGSIM.

Simulation Software:

7. Arena site.
8. FLEXSYM
9. SIMUL8 SIMUL8.
10. WITNESS WITNESS.
11. PROMODEL PROMODEL.
12. The Stat::Fit® vendor Geer Mountain Software Corporation Stat::Fit.

13. European Simulation Symposium, Marseille, République Française [France], 2001, Presentation. of Björn Johannson, a Ph.D. student at Chalmers University of Technology, Göteborg, Sverige [Sweden],
14. **A Collection of Modelling and Simulation Resources on the Internet**

PROTOCOL – CONDUCT (To do and not to do suggestions)

- Attendance is required. The attendance records will be submitted to university administrators as they need to know the dates you missed classes. The students need to enter attendance for F2F classes via current *LMS (learning Management system).*

  In case LMS doesn't function, either students will e-mail the instructor

- Homework: Homework problems are assigned weekly. It is due to the following week and need to be submitted at the beginning of the class online or manual as instructed - so that the HW can be solved in the class. Model Solutions are illustrated to give feedback to the students. Students are encouraged to present their solution/model. Not every hw will be graded, samples will be taken.

  Do not ask the instructor to accept your homework, after homework solutions are given out. Students can also submit their homework via e-mail in case LMS doesn't function

HW can be completed as a group but reports must be done individually . No computer modeling results can be graded without an analysis report with detailed explanations. Student must learn not only the programming but the theories/techniques to analyze the simulation program results. There will be series of questions in the class to test the overall class knowledge on the material covered. You can earn extra points by answering those questions. *Homework grade can be increased by taking active part in in-class solutions.*

Solving homework during the class and simply submitting programs with some answers, does not help you to improve your grade but just the opposite; these students miss the opportunity to learn the subject as well as miss the opportunity to take part in the solutions. **In this class you are graded by how much you take part in class activities and in class HW solutions rather than what you have submitted alone.**

- Exams & Quizzes:

Online classes: Exams are proctored by the instructor via WebEx.
F2F classes: Exams may be completed in two phase: 1st phase: students solve the questions that require manual calculations with simple calculators and submit the

answers, then 2nd phase: resolve the questions requiring computer use and submit the second set of answers.

Students can bring the formula sheet provided for the exam containing statistical formulations and tables. Students are expected to bring these formula sheets to every class and familiarize themselves with these equations/tables during the class rehearsal period.

- No Makeup Exam: There will be NO makeup exams, quizzes during the semester. In case of an extenuating circumstances such as illness, etc., where the student has a legitimate reason for missing the exam, student must notify Dean of Students, DOS@njit.edu and **the Instructor** why the exam will be missed and present written verifiable proof to confirm the reason for missing the exam, e.g., a doctors note, police report, court notice, etc., clearly stating the date AND time of the problem. **If only DOS** approves then only a makeup exam will be administered by the Instructor, or MIE department.

- Please take care of your personnel needs before the exam starts. You may not be allowed to leave the exam room.

- Only pencils, erasers and statistics formulae sheet and calculators are allowed on your exam table. Any other belonging must be kept away at one corner of the room, but not on the table or chair.

- Cell phones, beepers, ipods, palm pilots, etc. are not allowed under any circumstances in the room. *(Exceptional situations might require phone use-instructor must approve)*

- Anyone arriving more than 10 minutes after the exam starts will not be allowed to take the exam.

- Browsing class notes or Internet are not allowed for online classes. **Video must be turned on and point to student eyes at all times, breaks are not allowed during the exam.**
  F2F classes: Browsing into next's students exam paper or your notes during exams is not allowed. Hats, caps, etc., that keep the eyes hidden from the proctor , browsing the neighbors work during exams are not allowed. If you notice any student browsing any one else paper during the exam, it is your responsibility to report it quietly to your instructor. Otherwise you are giving an approval message to that person to continue.

- No eating is allowed during the class and exam periods. Please **respect** your classmate's need to concentrate in the class and behave civilized. Wait and try to use the break time between sessions for this purpose, if needed. You are expected to

remain in the class for the entire class period. Wandering in and out of the class is not recommended.

- **Further Assistance:** For further questions, students should contact their instructor. Office hours during the week are announced by the instructor in the first class. E-mail address is bengu@njit.edu

COURSE PROJECT SCHEDULE

3rd - 5th WEEK Team up with another classmate and submit your project proposal. Check the "required format and the guidelines" from the moodle course web site. Use table of contents to write about the methods you want to use in your project. Those who do not submit their project proposal will not be eligible to present their projects.

6th - 8th WEEK Complete a literature search on - your subject and any statistical analysis techniques you are employing- For example search for the following key words " an article about simulation Modeling of call centers " or " Health care centers" . Obtain at least 2 papers on your subject and review the papers and briefly summarize these related work. Follow these articles write up format for your project report.

9rd - 12th WEEK Build your model –Make required comparisions using statistical analysis techniques- Write your report Check your progress with your instructor. Follow up on the suggestions given.

LAST Day of class Make sure that you

1) upload your files to course website by that time and
2) submit a hard copy to instructor
or leave a copy in the mail box in the MIE dept. office, ME 332.

(Use your last names as filename; NamesProject.doc and follow project submission guidelines thoroughly)

FINAL EXAM DAY or LAST DAY of CLASSES (Exam 1 ½ hrs, Presentations 2 ½ hrs)

1) Upload your presentation files and report and ARENA files.
F2F: Bring your presentation material and load it on your computer and be ready to present.

2) F2F: Be in class by ½ hr early *(it takes time to get ready the computers and the projector)*

3) Instructor will provide the option of early presentation to those groups completed in advance.

If you want to present your project at an earlier date, you can do so by informing your instructor (1 month in advance) and submitting your material earlier.